Virginia City Hybrid Energy Center
Response to Data Request
Hullihen Moore, Virginia Air Pollution Control Board

Question (Page No. 5):

I recall that at the Mercury Conference several ways to reduce Mercury prior to combustion were discussed, including washing and treating. What are those techniques, how could they be applied to the coal for this plant, and what would the impact be?

Response:

Coal washing and treating are done for several reasons: increase heat content by lowering the fuels' ash content in order to allow the fuel to be consumed by pulverized coal boilers. When transporting the fuel over large distances, coal washing also has the benefit of reducing fuel transportation costs. In the case of VCHEC, the CFB boilers operate efficiently with a high ash fuel and the facility will be located in the vicinity of the coal sources thus already minimizing transportation costs.

At the Mercury Conference, a presentation was made by representatives of Virginia Tech called "Precombustion Control of Mercury Emissions". The presentation discussed several different washing/treating methods (wet and dry techniques) for coal. In the presentation, advanced separation techniques and developing technologies were referenced. Advanced separation was described as a wet separation process. Advanced separation requires the coal to be crushed down to a size no greater than 10mm (<0.4 inches). The current fuel plan has the facility receiving fuel in sizes up to 12 inches with the average size in the 2 to 3 inch range. Receiving coal at sizes less than 0.4 inches presents potential problems with the material handling, but more importantly causes problems in the combustion process. Wet coal treatment processes use significant amounts of water as well as energy.

Developing technologies discussed included dry coal separation, the MagMill system, and Activated Carbon Injection (ACI). The dry coal separation technique operates on the same principle as the wet technique, except air is used instead of water. The MagMill system is a dry magnetic separator system that separates impurities of coal using magnets at the tail end of a coal pulverizer. The MagMill system must be employed at the combustion source rather than at the mine due to moisture issues. The VCHEC will not be installing a pulverizer as this facility will employ CFB technology that requires coal "chunks" rather than pulverized or "powdered" coal. Therefore, this is not a technically feasible option. The last developing technology, ACI, is already proposed by Dominion to be installed which would make VCHEC the first CFB facility in the United States to install ACI.

Coal washing for this particular project is not appropriate nor does it represent BACT. First, CFB facilities require a higher ash content coal to maintain the bed (CFB boilers must maintain a bed of fluidized or "molten" material). The boilers designed for VCHEC cannot consume coal with a lower ash content than 10% or higher heat content than 12,000 Btu/lb without greatly reducing the amount of biomass than can be consumed (<5%) and adding an inert material (sand or gravel) to maintain the bed. Second, coal washing removes impurities from the run of mine coal such as ash by using the specific gravity differences between the coal and the impurities being removed. In order to separate the impurities from the coal, it is first crushed followed by washing based on the specific gravity of the impurity sought to be removed. Coal washing will not significantly reduce the unwanted impurities, such as sulfur and metals. The amount of reduction achieved depends on the chemical nature of the impurity.

Sulfur is present in coal in two forms, elemental and pyritic. Elemental sulfur has a specific gravity similar to coal so is not readily removed by coal washing. Pyritic sulfur, however, has a higher specific gravity than coal and is easier to remove. The pyritic sulfur content of southwest Virginia coal is less than in other coal regions (e.g., Northern Appalachian and Illinois basin) so coal washing of southwest Virginia coal will result in less sulfur reduction than washing of other coals.

Because of the form of sulfur typically found in southwest Virginia coal, coal washing is not as effective at removing SO_2 as the selected CFB and dry scrubber technologies proposed for VCHEC. Coal washing would reduce SO_2 emissions only negligibly or not at all, while the CFB and dry scrubber technologies would reduce SO_2 emissions by at least 98%.

Coal washing results in additional environmental impacts as a result of the waste coal piles generated. One of the goals of VCHEC is to build a CFB which can burn waste coal or "gob". According to the Virginia Department of Mines, Minerals and Energy; there are currently hundreds of waste coal piles in southwest Virginia. These waste coal piles pose environmental risks of water quality degradation, as well as potential fire hazards.

Run off from coal waste piles causes water pollution in the form of sedimentation of streams. The Department of Mines, Minerals and Energy (DMME) is conducting a study of the water quality impacts from these waste coal sites and it is our understanding the sediment loading from just one of these sites is contributing over 17,000 pounds per acre of sediment loading annually since the waste coal was deposited on the surface. This is just an example of one waste coal site. There have been significant comments in support of the VCHEC, because it will facilitate the use of waste coal piles in the region reducing sediment loading to streams and tributaries. See Exhibit 6 for a further discussion from the Department of Mines Minerals and Energy of the environmental benefits of waste coal reclamation on the Clinch River. Moreover, coal processing requires water. Using ROM coal rather than processed coal is consistent with VCHEC's commitment to minimize water consumption related to its operations (as evidenced by the use of air-cooled rather than water-cooled condensers).

In addition, these unreclaimed waste coal piles pose an air quality issue when they are ignited spontaneously. When a waste coal pile catches fire, uncontrolled emissions of sulfur dioxide, particulates, nitrogen oxides and mercury are released into the environment. Combusting the waste coal piles utilizing well-controlled, clean coal technology will reduce the potential for significant air emissions should these unreclaimed waste coal piles catch fire accidentally.

Mercury is a special metal HAP in that it can exist as a vapor at stack temperatures and depending on its speciation the control efficiency may vary. USEPA considered coal washing techniques during its development of a proposed MACT Floor for new coal-fired boilers in 2003. In a memorandum to Bill Maxwell of USEPA from Jeffrey Cole of RTI International entitled "MACT Floor Analysis for Coal- and Oil-Fired Electric Utility Steam Generating Units National Emission Standards for Hazardous Air Pollutants", December 2003, USEPA provides its evaluation of coal washing in regard to establishment of MACT Standards for new coal-fired units.

That report states "Pursuant to current EPA policy, the development of all MACT standards must consider, as a potential MACT control strategy, any pollution prevention techniques that could reduce or eliminate the pollutants of concern from being produced by the process." EPA considered the use of different coals, including pre-processing (washing). Analysis of the data collected by USEPA indicated that not all mercury contained in coal is created equal, citing differences in speciation of the mercury in the fuel as a major factor.

According to USEPA "The data show that although a coal may have a lower Hg loading in the coal, the Hg emissions may be more difficult to control if that seam of coal tends to speciate to Hg to an elemental form." Dominion's understanding is that washing of Virginia coal may reduce its mercury content by 5-30% (depending on the seam, mining technology, size distribution, differences in specific gravity, etc.). The reason that washing can reduce mercury at all is that some of the mercury present in ROM coal is bound in the rock (rock mercury) that is separated from coal during washing. The mercury that is contained in the structure of the coal itself is not believed to be affected by washing. EPA also determined that that mercury contained in rock is primarily released in the form of particulate mercury when burned in a CFB boiler, a form of mercury that is very efficiently collected. The "coal mercury", on the other hand, is substantially released as elemental mercury and much more difficult to capture.

Coal refuse, or waste coal, typically contains a higher concentration of Hg per ton of coal than high Btu, or washed bituminous coals. This is presumably because the waste coal includes all of the rock that had been historically washed out of ROM coal. However, EPA determined that CFB units firing waste coal emitted substantially less Hg from their stacks than those burning high Btu Eastern Bituminous coals. EPA went on to propose a MACT Floor for boilers that burn waste coal that was lower than for units burning high Btu washed Bituminous coal.

Dominion conducted the following control cost analysis for mercury removal on the basis of coal washing. The analysis is based on a comparison of the design coal which is 7,782 Btu/lb and a typical washed coal of 12,500 Btu/lb, and assuming a 0.3511 ppm mercury content (basis for the proposed limit of 49.46 lbs/yr) for the design coal and 0.2458 ppm mercury content (30% reduction from 0.3511) for the washed coal.

VCHEC Coal	Parameter	Washed Coal
7,782	Coal Heat Content (Btu/lb)	12,500
6,264	Boiler Rating (mmBtu/hr)	6264
3,525,613	Potential Annual Coal Consumption (tons)	2,194,906
0.3511	Coal Mercury Content (ppm)	0.2458
98.00%	Mercury Removal Efficiency	98.00%
2,476	Uncontrolled Mercury Emissions (lbs/yr)	1,079
49.5	Controlled Mercury Emissions (lbs/yr)	21.6
2,426	Mercury Removed (lbs/yr	1,057
$48.05	Cost of Coal ($/ton)	$109.52
$169,405,705	Annual Fuel Cost ($)	$240,386,105
$69,829	Average Cost of Mercury Removal ($/lb)	$227,423
	Incremental Cost of Mercury Removal ($/lb)	$2,544,100

As shown in the table, the cost of mercury removal for the washed coal scenario is $227,000/lb compared to less than $70,000/lb for the proposed VCHEC blend. Making the assumption that lowering the mercury concentration in the coal would have a direct relationship to lower mercury emissions, the cost to reduce controlled emissions from 49.5 lbs/yr to 21.6 lbs/yr goes to over $2.5 million/lb of mercury removed. $227,000/lb and $2.5 million/lb far exceed the commonly used benchmark of $35,000/lb.

Coal washing results in adverse energy impacts. Not only is substantial energy required to process the coal, about 15 to 20% of the coal mined ends up as coarse and fine coal waste. To recover the energy in that coal waste, a CFB is required. It is possible to estimate the energy in the carbon bearing materials that would be disposed of during coal processing. As an example, research conducted by Miltech Energy Services, Inc. at the Moss 3 mine waste coal piles indicate that there is about a 50% yield in converting ROM coals (~7,000 Btu/lbs) to higher grade processed coal having a heat content of approximately 12,000 Btu/lb. Coal processing refuse consists of 85% coarse coal, refuse containing about 2,000 Btu/lb and about 15% fine coal refuse containing about 4,000 Btu/lb. Therefore:

ROM Btu/lb = (0.50 x 12,000 Btu/lb) + (0.50 x 0.85 x 2,000 Btu/lb) + (0.50 x 0.15 x 4,000 Btu/lb) = 7,150 Btu / lb

ROM Btu Recovery % = (7,150 Btu/lb - 12,000 Btu/lb x 0.5) / (7,150 Btu/lb) x100 = 16%

Based on the data from Moss 3, this example shows that about 16% of the heat content contained in the ROM coal is lost in the coal cleaning process to refuse piles. This same heat content could be recovered to produce electricity by a CFB combusting the 7,150 Btu/lb ROM coal.

Processing coal also requires additional energy expenditures to operate the prep plant. Because there is insufficient water at the VCHEC site to support water cooling, much less coal processing, additional fuel would be consumed to transport the ROM from the variety of operators to a prep plant and then the processed coal to the power plant.

PM is controlled by a fabric filter (FF) baghouse. By washing the coal, the ash content would be reduced requiring less tons of fuel to accomplish the same heat output from the boiler. The greater ash content of the unwashed coal will result in a heavier ash loading to the baghouse, but is not expected to increase the plant emissions. The filter bags are physical devices that will block the ash from exiting the facility. Higher volumes of ash will require more frequent cleaning of the bags but will not increase the emissions significantly. This phenomenon is why the bag house efficiency increases with higher volumes of ash in the flue gas.

CO and VOC emissions will not be significantly impacted by coal washing. CO/VOC emissions are controlled by good combustion practices in the CFB. The combustion efficiency is limited by considerations for the development of NOx and the need to calcine limestone for SO2 removal. Using a higher BTU fuel, leads to a hotter bed temperature and increased thermal NOx.

Coal washing is not expected to reduce the pounds of sulfur (per heat input to the boiler) in the SW Virginia fuel since the sulfur is located in the coal and very little is removed during the washing process. Reduced sulfur in the washed coal could have the effect of reducing the amount of limestone that will need to be calcined in the boiler, thus reducing the amount of CO generated. Since the mass of sulfur into the boiler will be basically the same, the calcium to sulfur ratio will not change, so this effect of calcining the necessary limestone is not expected to have a significant impact.

Coal washing may reduce HAP metal emissions to varying degrees depending on where the metals are located. Metals are impurities in the coal and the surrounding rock. Impurities that are located in the surrounding rock will be reduced through the washing process and deposited with the waste coal. Metals can be in both the rock and the coal. When washing coal, the metals in the waste coal are sent to a slurry pond or waste coal pile. When ROM coal is consumed in the VCHEC boilers, those metals are controlled at more than 99%, then sent to a controlled landfill where they are encapsulated in a concrete-like ash. Information needed to quantify the reduction of metal HAPs from coal washing was not available to us.

Organic HAPs are generally in the coal matrix and acid gasses will be formed from chlorine and fluorine in the coal. Based on the MACT application the HAPs emissions expected from this facility are very low, due to the use of highly efficient backend pollution controls. The acid gasses are controlled by both the limestone injection into the boiler as well as the dry FGD unit. Metals are efficiently captured in the fabric filter and mercury is addressed with ACI technology.

There are advantages to processing the HAPs through this well controlled facility. The captured HAPs will end up in the ash from the facility. This ash will contain large quantities of calcium which will solidify and encapsulate the ash when water is added. Properly placed, the ash will be in a landfill, above the groundwater table with stormwater directed around it. In this condition the HAPs will be permanently sequestered.